



Ichthyofauna of the Gurgueia River, Parnaíba River basin, northeastern Brazil

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Abstract: The Gurgueia River in southern Piauí state, Brazil, is the largest affluent on the right margin of the Parnaíba River basin. This study aimed to inventory the Gurgueia River ichthyofauna, and contribute to the knowledge of fish diversity in Northeastern Brazil. We sampled 71 locations throughout the Gurgueia sub-basin between 2006 and 2014, which resulted in 90 fish species representing 67 genera, 26 families and six orders, including two non-native species. Six species are newly recorded for the Parnaíba basin (*Hasemania nana*, *Hemigrammus brevis*, *H. guyanensis*, *H. ora*, *Corydoras* sp. and *Cetopsorhamdia* sp.), increasing its freshwater ichthyofauna to 152 species. The Gurgueia River contains 59.2% of the ichthyofauna known for the Parnaíba basin, and can be used as a reference point for the establishment of priority areas for the conservation of the freshwater fish fauna of the Brazilian Northeast.

Key words: Neotropical region; Maranhão-Piauí Ecoregion; fishes of Caatinga and Cerrado; inventory

INTRODUCTION

The Parnaíba River is the largest drainage entirely located in Northeastern Brazil, and unlike most rivers in this region, it presents a perennial hydrologic regime. The Gurgueia River is the largest tributary on the right margin of the Parnaíba River, and is situated in the Caatinga and Cerrado biomes (SRH/MMA 2006). Due to its location in the upper portion of the Parnaíba River basin, the Gurgueia watershed is mainly under the influence of the Cerrado biome, one of the Neotropical biodiversity hotspots identified by Myers et al. (2000).

The first expeditions to the Parnaíba River basin included ichthyological explorations of the Gurgueia

River. Those involved renowned naturalists and ichthyologists such as Johann B. von Spix in 1818-1819, Orestes Saint-John in 1865-1866, Franz Steindachner in 1903, and John D. Haseman in 1908 (Roberts 1968; Vanzolini 1992; Olmos and Brito 2007; Ramos 2012). Those expeditions resulted in the descriptions of several species endemic to the Parnaíba River basin, such as *Prochilodus lacustris* Steindachner, 1907, *Hemiodus parnaguae* Eigenmann & Henn, 1916, and *Pterygoplichthys parnaibae* (Weber, 1991), all sharing the type locality in Parnaguá Lagoon, Gurgueia sub-basin (Ramos 2012).

The headwaters of Gurgueia River are located in the Chapada das Mangabeiras, in the Nascentes do Rio Parnaíba National Park (NPNP), one of the Brazilian Federal conservation units, which was created in 2002 with the main goal of safeguarding the sources of the rivers that drain this basin (Ministério do Meio Ambiente 2007). The confluence of the Gurgueia and Parnaíba rivers is immediately downstream of Boa Esperança Hydroelectric Power Plant and is the limit between the upper and middle portions of the basin (Ramos 2012). Much of the Gurgueia River is located in a region of intense agricultural growth, and the watershed is subjected to impacts such as riparian forest removal, siltation and run-off contaminated with fertilizers and pesticides (SRH/MMA 2006).

Ramos et al. (2014) conducted a broad fish taxonomic study of the Parnaíba that increased the known endemism and richness of the basin. Their study also pointed out the necessity for more sampling in headwater areas that can shelter endemic species with restricted distributions. Therefore, the main goals of this study were to inventory the Gurgueia River ichthyofauna, to expand the knowledge of fish diversity

in the Brazilian Northeast, and to suggest strategies for the management and conservation of this fauna.

MATERIALS AND METHODS

Study area

The headwaters of the Gurgueia River drain the foothills of the “Chapada das Mangabeiras”, in the municipality of Corrente, southern Piauí state, limited by $43^{\circ}00' S$ to $45^{\circ}30' S$, and $06^{\circ}45' W$ to $10^{\circ}45' W$. The Gurgueia River flows north, and joins the Parnaíba River below Boa Esperança hydroelectric power plant, in Floriano municipality, Piauí.

The sub-basin of the Gurgueia River is within the Cerrado vegetation complex, receiving water from the extreme southwest of the “Chapada das Mangabeiras” and the “Serra da Tabatinga”, near the border of Bahia state. The main course of the Gurgueia River is perennial along its 532 km in length, and its main tributaries are the Paraim, Corrente, Canhoto, and Esfolado Rivers, plus the Tábua and Santana streams and two large lagoons, Parnaguá and Peixe (SRH/MMA 2006).

The Gurgueia sub-basin drains, totally or partially, 33 municipalities in Piauí. The soils of the region are predominantly sedimentary, with a relatively small part of the sub-basin consisting of a crystalline foundation (SRH/MMA 2006). The average annual rainfall in southern Piauí is approximately 700 to 1,300 mm, with

a high concentration of rainfall between the months of November and March (Silva et al. 2013).

The Gurgueia River flows over predominantly sand and clay soils, with some rocky substrate stretches. The riparian vegetation varies from undisturbed stretches, especially in NPNP’s headwaters, to completely deforested portions for agriculture and construction. The water is clear during most of the year, but in the rainy season it becomes turbid and turbulent.

Data collection

The study was conducted between 2006 and 2014 with samples taken from 71 sites throughout the Gurgueia River sub-basin (Figure 1; Table 1) in variable periods between droughts and floods. The collection effort was “AquaRAP” (Rapid Assessment Protocol in Aquatic Systems, Alonso and Willink 2011) and the fishes were collected with sieves, dip nets, trawl nets, cast nets, traps and hooks (Collection permit: ICMBio n° 20.088-4/2014). We collected fishes in intermittent and perennial ponds and in the main channel and tributaries of the Gurgueia River, involving teams of the Federal Universities of Piauí (UFPI), Pernambuco (Rural/UFRPE), Paraíba (UFPB), and Rio Grande do Norte (UFRN) states.

The collected specimens were fixed in a 10% aqueous formalin solution for a minimum period of eight

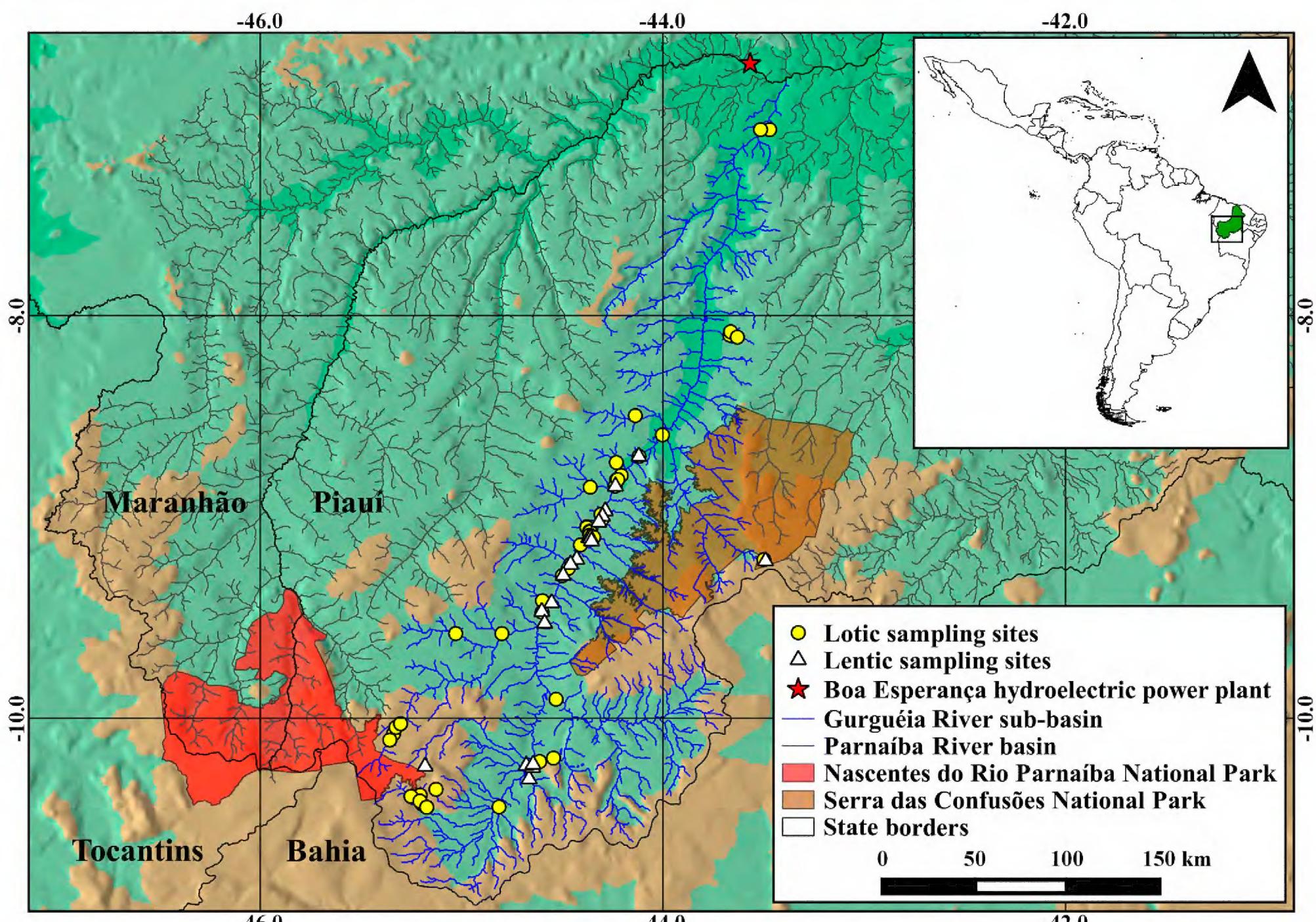


Figure 1. Location of Gurgueia River sub-basin, Parnaíba River basin, Piauí state, Brazil, showing sampling sites.

days, and then transferred to a 70% alcohol solution. Sorting and species identification occurred in the Zoology laboratories at UFPI, Campus Professora Cinobelina Elvas, Bom Jesus municipality, Piauí state; Systematics and Morphology of Fishes at UFPB, João Pessoa municipality, Paraíba state, and Systematic and Evolutionary Ichthyology at UFRN, Natal municipality, Rio Grande do Norte state. Specimens were deposited in fish collections of the Department of Systematics and Ecology at UFPB and Department of Botany and Zoology at UFRN (Table 2).

Meristic and morphometric data for identification were collected according to the methods of Hubbs and Lagler (2006), with the aid of a stereoscopic microscope and calipers. Identifications were based on specialized literature (Britski et al. 1984; Kullander 1988; Ploeg 1991; Ramos 2012), and the assistance of experts. Classification of species followed Eschmeyer (2015). The taxonomic terms were used as follows: *aff.* for species that have affinity with, but should be distinct from the

nominal taxon to which they are assigned; *cf.* for species of doubtful identity that need to be checked; and *sp.* for undescribed species.

RESULTS

Samples from 71 locations yielded a total of 4,312 specimens representing 90 species in 67 genera, 26 families and six orders of freshwater fishes (Tables 1 and 2). Some orders were represented by few species, such as the Cyprinodontiformes with two species (*Melanorivulus parnaibensis* and *Pamphorichthys hollandi* - 2.2%) and Myliobatiformes with only one species (*Potamotrygon signata* - 1.1%) (Figure 2). The highest species richness values were registered for Characiformes with 48 species (53.3%) and Siluriformes with 30 (33.3%). Species of Characiformes were distributed in 33 genera and 11 families, and the Siluriformes in 21 genera and seven families. The high species richness values of these orders is a pattern that Ramos et al. (2014) noted in the Parnaíba River basin, and follows the general pattern for

Table 1. Sampling sites in Gurgueia River sub-basin, Parnaíba River basin, Piauí state, Brazil.

ID	Sampling sites	Latitude	Longitude
1	Tají River, Corrente.	10°22'53.3" S	045°12'21.3" W
2	Corrente River, under bridge on highway BR 135, Corrente.	10°25'30.6" S	045°11'47.4" W
3	Corrente River, Corrente.	10°21'09.4" S	045°07'38.2" W
4	Corrente River, Corrente.	10°23'14.8" S	045°15'05.9" W
5	Unnamed Stream, Corrente.	10°24'39.3" S	045°12'24.9" W
6	Headwaters of the Gurgueia River, São Gonçalo do Gurgueia.	10°04'38.7" S	045°20'18.2" W
7	Corrente River, under bridge on highway BR 135, Corrente.	10°26'29.4" S	045°10'24.3" W
8	Gurgueia River, under bridge on highway BR-135, São Gonçalo do Gurgueia.	10°01'37.1" S	045°18'12.3" W
9	Temporary pool in the margin on highway BR-135, Corrente.	10°14'19.3" S	045°10'53.9" W
10	Gurgueia River, Araras Park, Corrente.	10°06'27.0" S	045°21'24.0" W
11	Gurgueia River, Corrente.	10°02'41.6" S	045°19'33.6" W
12	Unnamed stream, highway BR-135, Eliseu Martins.	08°05'51.3" S	043°40'02.2" W
13	Santana River, highway BR-135, Alvorada do Gurgueia.	08°35'31.2" S	044°00'08.7" W
14	Gurgueia River, Cristino Castro.	08°48'55.7" S	044°13'47.8" W
15	Marginal pond of the Gurgueia River, highway BR-135, Cristino Castro.	08°58'16.4" S	044°17'09.8" W
16	Unnamed stream, Bom Jesus.	09°00'44.1" S	044°18'10.5" W
17	Unnamed stream, Bom Jesus.	09°05'24.5" S	044°21'46.4" W
18	Matões Stream, highway BR-135, Bom Jesus.	09°14'08.7" S	044°27'31.6" W
19	Unnamed stream, highway BR-135, Bom Jesus.	09°17'32.4" S	044°29'59.0" W
20	Unnamed stream, highway BR-135, Bom Jesus.	09°24'58.3" S	044°35'54.5" W
21	Águas Claras Marsh, highway BR-135, Brejo dos Paus Village, Redenção.	09°34'46.8" S	044°47'59.2" W
22	Contrato River, Contrato Village.	09°34'45.8" S	045°01'45.6" W
23	Gurgueia River, São Gonçalo do Gurgueia.	10°01'36.4" S	045°18'11.2" W
24	Jurema Marsh, highway BR-135, Corrente.	10°26'29.0" S	045°10'23.6" W
25	Corrente River, under bridge on highway BR-135, Corrente.	10°26'29.0" S	045°10'23.6" W
26	Paraim River, highway PI-255, Parnaguá.	10°26'23.9" S	044°48'50.8" W
27	Parnaguá Lagoon, highway PI-255, Parnaguá.	10°18'04.5" S	044°39'53.1" W
28	Parnaguá Lagoon, Parnaguá.	10°14'40.0" S	044°38'49.3" W
29	Parnaguá Pond, left margin, Parnaguá.	10°14'01.9" S	044°40'43.8" W
30	Oco Stream, highway PI-255, Parnaguá.	10°12'53.0" S	044°36'44.9" W
31	Unnamed stream, highway PI-255, Parnaguá.	10°11'50.0" S	044°32'36.4" W
32	Gurgueia River, Sucuri Ranch, Cristino Castro.	08°41'56.6" S	044°07'07.1" W
33	Perennial pond, Ely Garrote Ranch, Cristino Castro.	08°41'56.9" S	044°07'10.6" W
34	Brejo Novo Stream, Palmeira do Piauí.	08°43'43.2" S	044°13'52.8" W
35	Estreito Stream, highway BR-135, Cristino Castro.	08°47'36.0" S	044°12'26.2" W
36	Gurgueia River, Petrônio Falcão Ranch, highway BR-135, Cristino Castro.	08°50'48.6" S	044°14'13.7" W

Continued

Table 1. Continued.

ID	Sampling sites	Latitude	Longitude
37	Intermittent pond, Petrônio Falcão Ranch, highway BR-135, Cristino Castro.	08°50'50.1" S	044°14'09.1" W
38	Gurgueia River, José Martins Ranch, highway BR-135, Cristino Castro.	08°29'46.7" S	044°08'13.8" W
39	Gurgueia River, França Ranch, Cristino Castro.	08°48'49.1" S	044°13'28.3" W
40	Corrente Pará Stream, Currais.	08°51'06.7" S	044°21'40.0" W
41	Gurgueia River, Bela Cave, Bom Jesus.	08°59'16.0" S	044°18'26.0" W
42	Melancia Pond, Santa Luz.	08°59'53.5" S	044°17'59.8" W
43	Unnamed stream, Barra Verde Village, highway BR-135, Bom Jesus.	09°14'09.6" S	044°27'32.8" W
44	Xuxa Pond, Bela Cave, Bom Jesus.	09°01'34.6" S	044°19'06.2" W
45	Palmeirinha Stream, Bom Jesus.	09°02'56.6" S	044°22'40.1" W
46	Palmeirinha Stream, Bom Jesus.	09°03'09.7" S	044°21'23.1" W
47	Gurgueia River, Bom Jesus.	09°03'09.7" S	044°22'40.1" W
48	Grotão Stream, Bom Jesus.	09°04'21.0" S	044°21'52.6" W
49	Grotão Stream, Bom Jesus.	09°04'27.5" S	044°21'41.7" W
50	Cedro Stream, Bom Jesus.	09°05'26.7" S	044°21'46.9" W
51	Bom Jesus Marsh, highway BR 135, Bom Jesus.	09°06'04.5" S	044°20'40.1" W
52	Adelaide Pond, Alto da Cruz Village, highway BR-135, Bom Jesus.	09°06'12.5" S	044°22'05.2" W
53	Perennial pond, Vila Estela Ranch, Bom Jesus.	09°06'21.9" S	044°21'32.3" W
54	Barro Pond, Bom Jesus.	09°07'14.6" S	044°21'16.3" W
55	Unnamed stream, São Felipe Ranch, Bom Jesus.	09°08'22.6" S	044°24'35.3" W
56	Tanazio Pond, Eugenópolis, Bom Jesus.	09°12'40.0" S	044°25'41.3" W
57	Tamboril Pond, Barra Verde, Bom Jesus.	09°14'09.6" S	044°27'32.8" W
58	Resfriado Stream, Bom Jesus.	09°15'20.9" S	044°28'13.8" W
59	Rabeca Pond, Couve Village, Bom Jesus.	09°17'28.2" S	044°29'43.5" W
60	Altamira Pond, Redenção do Gurgueia.	09°25'37.5" S	044°33'09.2" W
61	Angical Pond, highway BR-135, Km 413, Redenção do Gurgueia.	09°28'14.1" S	044°36'05.9" W
62	Gurgueia River, highway BR 135, Km 413, Redenção do Gurgueia.	09°28'24.8" S	044°36'02.3" W
63	Pedrinhas Pond, Redenção do Gurgueia.	09°31'44.1" S	044°35'15.5" W
64	Pedrinhas Stream, Curimatá.	09°54'20.0" S	044°31'50.1" W
65	Parnaguá Pond, Parnaguá.	10°13'44.8" S	044°38'41.3" W
66	Tributary of the Buriti Stream, Eliseu Martins.	08°04'48.1" S	044°39'49.6" W
67	Buriti Stream, highway PI-141, Eliseu Martins.	08°06'25.3" S	043°37'48.6" W
68	Unnamed stream at Serra das Confusões National Park.	09°12'46.9" S	043°29'55.2" W
69	Unnamed pond at Serra das Confusões National Park.	09°13'08.8" S	043°29'24.7" W
70	Gurgueia River, under bridge on highway PI-218, Jurumenha.	07°04'36.2" S	043°28'11.0" W
71	Gurgueia River, Jurumenha.	07°04'36.7" S	043°30'54.0" W

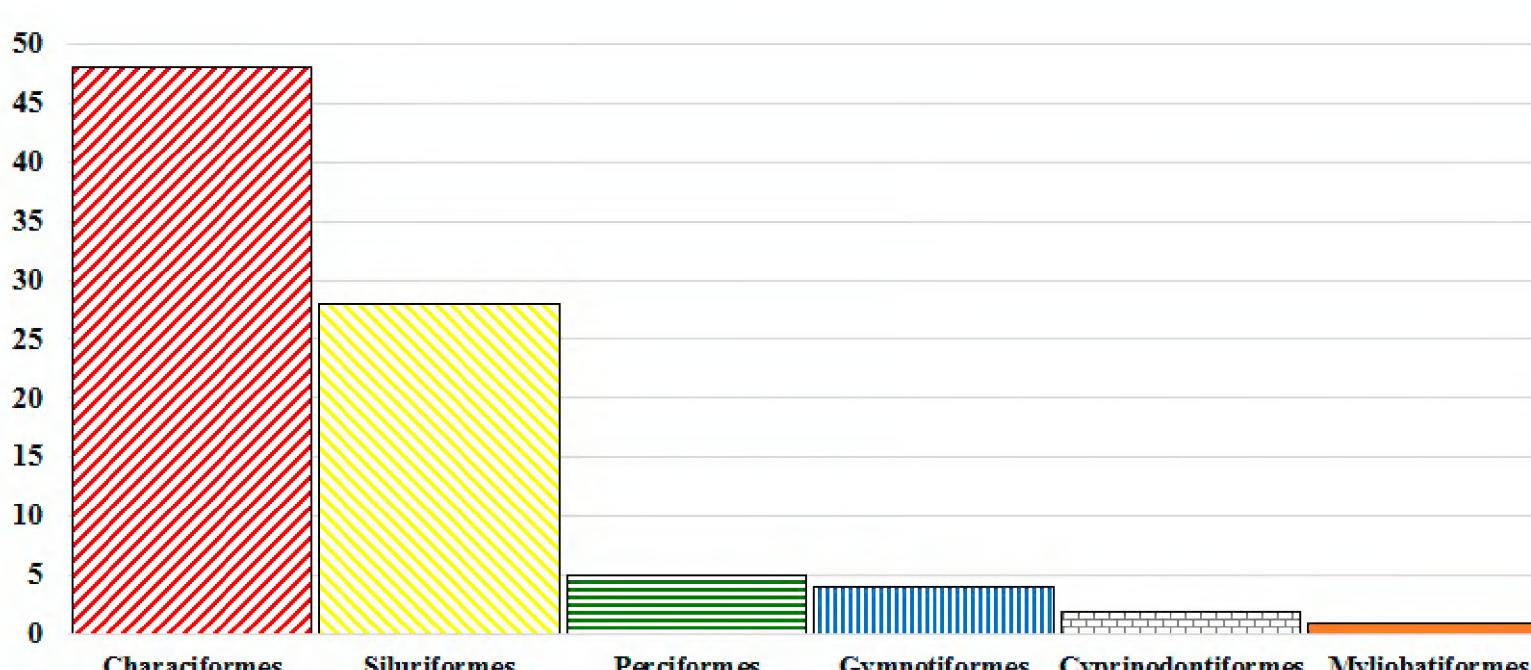
Table 2. List of fish species of Gurgueia River sub-basin, Parnaíba River basin, Piauí state, Brazil. E = Endemic species of Parnaíba River basin, NN = Non-native species, X = same species recorded by Ramos et al. (2014), and New Record = first record in the Parnaíba River basin.

Taxon	Ramos et al. (2014)	Voucher	Taxon	Ramos et al. (2014)	Voucher
ORDER MYLIOBATIFORMES					
Family Potamotrygonidae			Family Crenuchidae		
<i>Potamotrygon signata</i> Garman, 1913 ^(E)	X	UFRN 3378	<i>Characidium cf. bahiense</i> Almeida, 1971	X	UFPB 9996
ORDER CHARACIFORMES			<i>Characidium bimaculatum</i> Fowler, 1941	X	UFRN 3379
Family Parodontidae			<i>Characidium zebra</i> Eigenmann, 1909	X	UFRN 2709
<i>Apareiodon</i> sp. 1	<i>Apareiodon davi</i>	UFRN 2774	<i>Characidium</i> sp. 1	X	UFRN 2784
<i>Apareiodon</i> sp. 2	<i>Apareiodon</i> sp.	UFRN 2746	<i>Characidium</i> sp. 2	X	UFRN 2843
Family Curimatidae			Family Hemiodontidae		
<i>Curimatella immaculata</i> (Fernández-Yépez, 1948)	X	UFPB 9994	<i>Hemiodus parnaguae</i> Eigenmann & Henn, 1916 ^(E)	X	UFPB 10005
<i>Curimata macrops</i> (Eigenmann & Eigenmann, 1889) ^(E)	X	UFPB 10008	Family Characidae		
<i>Steindachnerina notonota</i> (Miranda Ribeiro, 1937)	X	UFRN 2759	<i>Astyanax aff. bimaculatus</i> (Linnaeus, 1758)	X	UFRN 2710
Family Prochilodontidae			<i>Astyanax aff. fasciatus</i> (Cuvier, 1819)	X	UFRN 2707
<i>Prochilodus lacustris</i> Steindachner, 1907 ^(E)	X	UFPB 9995	<i>Brachychalcinus parnaibae</i> Reis, 1989 ^(E)	X	UFRN 3380
Family Anostomidae			<i>Bryconamericus</i> sp.	X	UFRN 2889
<i>Leporinus friderici</i> (Bloch, 1794)	X	UFRN 2725	<i>Compsura heterura</i> Eigenmann, 1915	X	UFRN 2715
<i>Leporinus obtusidens</i> Valenciennes, 1836	X	UFPB 10015	<i>Hasemania nana</i> (Lütken, 1875)	New Record	UFRN 2874
<i>Leporinus piau</i> Lutken, 1875	X	UFRN 2724	<i>Hemigrammus brevis</i> Ellis, 1911	New Record	UFPB 7349
<i>Schizodon dissimilis</i> (Garman, 1890) ^(E)	X	UFPB 9956	<i>Hemigrammus guyanensis</i> Géry, 1959	New Record	UFPB 7345
			<i>Hemigrammus marginatus</i> Ellis, 1911	X	UFRN 2840
			<i>Hemigrammus ora</i> Zarske, Le Bail & Géry, 2006	New Record	UFPB 7350

Continued

Table 2. Continued.

Taxon	Ramos et al. (2014)	Voucher	Taxon	Ramos et al. (2014)	Voucher
<i>Jupiaba polylepis</i> (Günther, 1864)	X	UFPB 10012	<i>Pterygoplichthys parnaibae</i> (Weber, 1991) ^(E)	X	UFRN 3387
<i>Knodus victoriae</i> (Steindachner, 1907) ^(E)	X	UFRN 2711	Family Heptapteridae		
<i>Moenkhausia sanctaefilomenae</i> (Steindachner, 1907)	X	UFRN 2706	<i>Cetopsorhamdia</i> sp.	New Record	UFRN 3356
<i>Moenkhausia</i> sp.	X	UFPB 9992	<i>Imparfinis</i> sp.	X	UFRN 2716
<i>Phenacogaster calverti</i> (Fowler, 1941)	X	UFRN 2740	<i>Pimelodella parnabyae</i> Fowler, 1941 ^(E)	X	UFRN 2733
<i>Poptella compressa</i> (Günther, 1864)	X	UFPB 10013	<i>Pimelodella</i> cf. <i>steindachneri</i> Eigenmann, 1917	X	UFRN 3388
<i>Psellogrammus kennedyi</i> (Eigenmann, 1903)	X	UFPB 9993	<i>Phenacorhamdia</i> sp.	X	UFRN 2768
<i>Roeboides margaretae</i> Lucena, 2003 ^(E)	X	UFPB 10009	Family Doradidae		
<i>Roeboides sazimai</i> Lucena, 2007 ^(E)	X	UFPB 10016	<i>Hassar affinis</i> (Steindachner, 1881)	X	UFRN 3389
<i>Serrapinnus heterodon</i> (Eigenmann, 1915)	X	UFRN 2714	<i>Platydoras brachylepis</i> Piorski, Garavello, Arce H. & Sabaj Pérez, 2008	X	UFRN 3390
<i>Serrapinnus piaba</i> (Lütken, 1875)	X	UFPB 10017	Family Auchenipteridae		
<i>Serrapinnus</i> sp.	X	UFRN 2754	<i>Auchenipterus menezesi</i> Ferraris & Vari, 1999 ^(E)	X	UFRN 3391
<i>Tetragonopterus argenteus</i> Cuvier, 1816	X	UFRN 3381	<i>Trachelyopterus galeatus</i> (Linnaeus, 1766)	X	UFPB 10002
Family Iguanodectidae			Family Pimelodidae		
<i>Bryconops</i> cf. <i>melanurus</i> (Bloch, 1794)	X	UFRN 2713	<i>Hemisorubim platyrhynchos</i> (Valenciennes, 1840)	X	UFRN 3392
Family Serrasalmidae			<i>Pimelodus blochii</i> Valenciennes, 1840	X	UFPB 7886
<i>Colossoma macropomum</i> (Cuvier, 1816) ^(NN)	X	UFRN 3382	<i>Pimelodus maculatus</i> La Cepède, 1803	X	UFRN 2804
<i>Metynnis lippincottianus</i> (Cope, 1870)	X	UFPB 10001	<i>Pimelodus</i> sp. 1	X	UFPB 7297
<i>Pygocentrus nattereri</i> Kner, 1858	X	UFPB 10014	<i>Pimelodus</i> sp. 2	X	UFRN 3055
<i>Serrasalmus rhombeus</i> Lütken, 1875	X	UFRN 3383	<i>Pseudoplatystoma fasciatum</i> (Linnaeus, 1766)	X	UFPB 10003
Family Triportheidae			<i>Sorubim lima</i> (Bloch & Schneider, 1801)	X	UFRN 3393
<i>Triportheus signatus</i> (Garman, 1890)	X	UFRN 2805	ORDER GYMNOTIFORMES		
Family Acestrorhynchidae			Family Gymnotidae		
<i>Acestrorhynchus falcatus</i> (Bloch, 1794)	X	UFRN 2807	<i>Gymnotus carapo</i> Linnaeus, 1758	X	UFRN 3394
Family Erythrinidae			Family Hypopomidae		
<i>Hoplerythrinus unitaeniatus</i> (Spix & Agassiz, 1829)	X	UFRN 3384	<i>Brachyopomus</i> sp.	X	UFRN 3395
<i>Hoplias malabaricus</i> (Bloch, 1794)	X	UFRN 2739	Family Sternopygidae		
ORDER SILURIFORMES			<i>Eigenmannia virescens</i> (Valenciennes, 1842)	X	UFPB 10004
Family Callichthyidae			<i>Sternopygus macrurus</i> (Bloch & Schneider, 1801)	X	UFRN 3396
<i>Aspidoras raimundi</i> (Steindachner, 1907) ^(E)	X	UFRN 3339	ORDER CYPRINODONTIFORMES		
<i>Callichthys callichthys</i> (Linnaeus, 1758)	X	UFRN 3385	Family Rivulidae		
<i>Corydoras julii</i> Steindachner, 1906	X	UFPB 9997	<i>Melanorivulus parnabensis</i> (Costa, 2003) ^(E)	X	UFPB 10011
<i>Corydoras vittatus</i> Nijssen, 1971	X	UFPB 9998	Family Poeciliidae		
<i>Corydoras</i> sp.	New Record	UFRN 3346	<i>Pamphorichthys hollandi</i> (Henn, 1916)	X	UFPB 10010
<i>Hoplosternum littorale</i> (Hancock, 1828)	X	UFRN 3386	ORDER PERCIFORMES		
Family Loricariidae			Family Sciaenidae		
<i>Ancistrus damasceni</i> (Steindachner, 1907) ^(E)	X	UFRN 2719	<i>Plagioscion squamosissimus</i> (Heckel, 1840)	X	UFPB 10006
<i>Hypostomus johnii</i> (Steindachner, 1877) ^(E)	X	UFRN 2705	Family Cichlidae		
<i>Hypostomus</i> sp. 1	X	UFRN 2718	<i>Cichlasoma sanctifranciscense</i> Kullander, 1983	X	UFPB 9999
<i>Hypostomus</i> sp. 2	X	UFRN 2720	<i>Crenicichla menezesi</i> Ploeg, 1991	X	UFRN 2712
<i>Loricaria parnabyae</i> Steindachner, 1907 ^(E)	X	UFRN 2717	<i>Geophagus parnabae</i> Staack & Schindler, 2006 ^(E)	X	UFPB 10007
<i>Loricariichthys derbyi</i> Fowler, 1915	X	UFPB 7797	<i>Oreochromis niloticus</i> (Linnaeus 1758) ^(NN)	X	UFRN 3397
<i>Parotocinclus</i> sp.	X	UFRN 2846			

**Figure 2.** Number of species by order caught in the Gurgueia River sub-basin (Parnaíba River basin, Piauí state, Brazil).

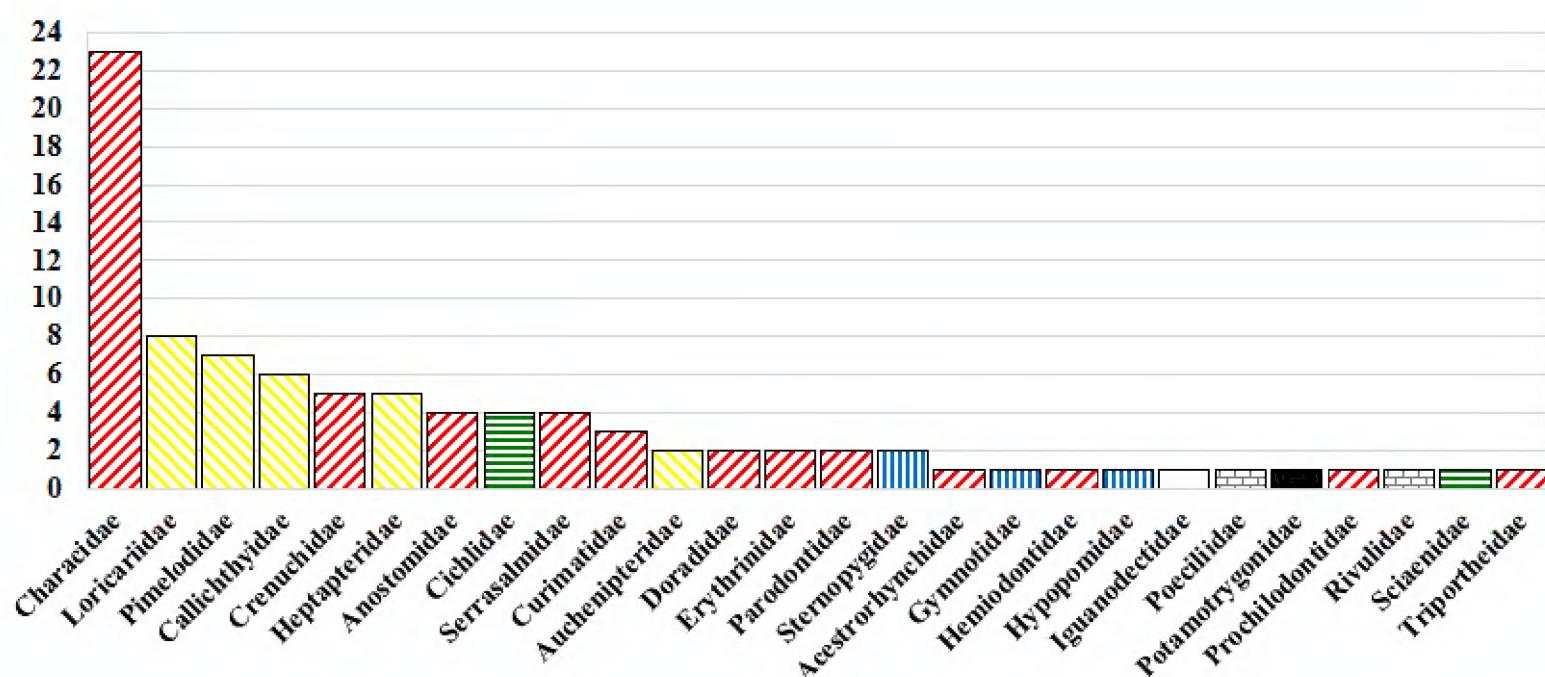


Figure 3. Number of species by family caught in the Gurgueia River sub-basin (Parnaíba River basin, Piauí state, Brazil). Families in the same order share the same color pattern.

other Brazilian river basins (Buckup et al. 2007) and for the entire Neotropical region (Reis et al. 2003).

The most representative families were the Characidae (Characiformes) with 23 species (25.5%), followed by the Loricariidae (Siluriformes), with eight (8.9%), and Pimelodidae with seven (7.8%). Ten families were represented by a single species (Aestrorhynchidae, Gymnotidae, Hemiodontidae, Hypopomidae, Poeciliidae, Potamotrygonidae, Prochilodontidae, Rivulidae, Sciaenidae and Triportheidae) (Figure 3).

Of the 90 species recorded in the Gurgueia River sub-basin, 17 are undescribed, 34 are endemic to the Parnaíba basin and two were introduced: “Tilapia” *Oreochromis niloticus* and “Tambaqui” *Colossoma macropomum*, both used as food by riverside communities (Table 2). Local fishermen also reported the presence of hybrids of *Colossoma macropomum* and “Pacu” *Piaractus mesopotamicus* (Holmberg, 1887). Aside from *Hasemania nana*, *Hemigrammus brevis*, *H. guyanensis*, *H. ora* and two undescribed species, one of the genus *Cetopsorhamdia* and other of the genus *Corydoras*, all species sampled in this study had previously been recorded in the Parnaíba basin by Ramos et al. (2014).

DISCUSSION

Albert et al. (2011) suggested that 95 species inhabit the Maranhão-Piauí Ecoregion which includes, besides the Parnaíba River basin, the Munim River basin and small coastal basins (Riachão Stream, Bom Sossego Stream, Piriá River, Preguiça or Grande River, Fome River, Barro Duro River and others), in Maranhão state. In addition, Albert et al. (2011) suggested that 20 species (21%) are endemic to the Maranhão-Piauí Ecoregion. Ramos et al. (2014), focusing only on the Parnaíba basin, listed the presence of 146 species, including 27 new records for the basin, 54 endemic species, 27 undescribed, and seven non-native.

With six species newly recorded in this study, the freshwater ichthyofauna of the Parnaíba River is expanded to 152 species, of which 59.2% (90 species including two non-natives) were recorded in the Gurgueia River sub-basin. Thus, the basin of the Gurgueia River encompasses a large portion of the Parnaíba River ichthyofauna, suggesting that this area can be considered as a priority for the conservation of the fish diversity in this ecoregion. Although the area surrounding the Gurgueia River encompasses two National Parks (NPNP and Serra das Confusões National Park, SCNP), the sub-basin is underprotected, since only small portions of its water bodies are included in these protected areas. Thus, future expansions of protected areas should include a greater representation of the hydrographic network (Santos and Tabarelli 2003). No water body was found inside the NPNP area during the July 2014 collections, and only two localities in the SCNP could be sampled, in which only three species (*Astyanax* aff. *bimaculatus* *Serrapinnus heterodon* and *H. malabaricus*) were recorded.

Another important factor that calls attention to the protection of this sub-basin are records of the electric knifefish *Brachyopomus* sp. (four specimens), and catfish *Cetopsorhamdia* sp. (one specimen). These species are not yet described due to small sample sizes, and were recorded only in the upper Gurgueia River sub-basin.

Among the new records in the Parnaíba River basin, *Hasemania nana* and *Hemigrammus brevis* were previously considered endemic to the São Francisco basin; meanwhile *Hemigrammus guyanensis* and *H. ora* were originally recorded for French Guiana (Reis et al. 2003; Zarske et al. 2006). Jerep et al. (2011) extended the distribution of *H. ora* into tributaries of lower Amazon and the upper portions of the Xingu and Tocantins-Araguaia basins. These new records in Parnaíba demonstrate the need for further ichthyofaunal

research in the upper portion of the Parnaíba drainage, as suggested by Ramos et al. (2014).

No endangered species were recorded in the Gurgueia River sub-basin (for list of endangered taxa, see Ministério do Meio Ambiente 2014). Ramos et al. (2014) listed *Apareiodon davisii*, currently classified as “endangered”, for the Parnaíba basin. The same species was collected in the Gurgueia River sub-basin and referred to here as *Apareiodon* sp. 1 [*Apareiodon davisii* *sensu* Ramos (2014)]. More detailed analysis involving parodontid species is needed to determine if *Apareiodon* sp. 1 is an undescribed species (C. Pavanelli pers. comm.).

Knowledge of the ichthyofauna in the Parnaíba River has increased in the last few years due to the sampling efforts of regional research groups. Such information, however, remains limited and hinders an accurate assessment of fish conservation in Piauí state. Several areas of the main hydrographic sub-basins of the Parnaíba River, especially those away from the main course of the river, lack more accurate inventories commensurate with the one provided by this study. It is important to note that many of the species recorded in the Gurgueia River, as well as the Parnaíba basin, lack taxonomic, natural history and ecological studies to assess their total distribution and population density (Ramos et al. 2014). This information is crucial for monitoring anthropogenic modifications related mainly to accelerated agricultural practices in the Cerrado, and ongoing and future hydroelectric projects.

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LITERATURE CITED

Albert, J.S., P. Petry and R.E. Reis. 2011. Major biogeographic and phylogenetic patterns; pp. 21-57, in: J.A. Albert and R.E. Reis (eds.). *Historical biogeography of neotropical freshwater fishes*. Berkeley and Los Angeles: University of California Press.

Alonso, L.E. and P. Willink. 2011. History and overview of AquaRAP; pp. 80-91, in: L.E. Alonso, L.E., J.L. Deichmann, S.A. McKenna, P. Naskrecki and S.J. Richards (eds.). *Still counting...: Biodiversity exploration for conservation — the first 20 years of the Rapid Assessment Program*. Arlington: Conservation International. 316 pp. <https://library.conservation.org/Published%20Documents/RAP%2020%20Year%20Book%20final%20pdf%2003-03-11.pdf>

Britski, H.A., Y. Sato and A.B.S. Rosa. 1984. *Manual de identificação de peixes da região de Três Marias (com chaves de identificação para os peixes da bacia do São Francisco)*. Brasília: Câmara dos Deputados, Coordenação de Publicação/CODEVASF Divisão de Piscicultura e Pesca. 143 pp.

Buckup, P.A., N.A. Menezes and M.S. Ghazzi. 2007. *Catálogo das espécies de peixes de água doce do Brasil*. Rio de Janeiro: Museu Nacional. 195 pp.

Eschmeyer, W.N. (ed.). 2015. Catalog of fishes: genera, species, references. Accessed at <http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>, 27 April 2015.

Hubbs, C.L. and K.F. Lagler. 2006. *Fishes of the Great Lakes region*. Ann Arbor: University of Michigan Press. 213 pp.

Jerep, F.C., F.R. Carvalho and V.B. Bertaco. 2011. Geographic distribution of *Hemigrammus ora* (Ostariophysi: Characiformes: Characidae) in the Amazon basin, Brazil. *Zoologia (Curitiba)* 28(4): 545-550. doi: [10.1590/S1984-46702011000400019](https://doi.org/10.1590/S1984-46702011000400019)

Kullander, S.O. 1988. A revision of the South American cichlid genus *Cichlasoma* (Teleostei: Cichlidae). Sweden: Swedish Museum of Natural History. 296 pp.

Ministério do Meio Ambiente. 2007. *Áreas prioritárias para conservação, uso sustentável e repartição de benefícios da biodiversidade brasileira: atualização — Portaria MMA 9/2007*. Brasília: MMA – Secretaria de Biodiversidade e Florestas. 300 pp.

Ministério do Meio Ambiente. 2014. Portaria nº 445, de 17 de Dezembro de 2014. *Lista Nacional Oficial de Espécies da Fauna Ameaçada de Extinção: Peixes e Invertebrados Aquáticos*. Brasília: Diário Oficial da União. pp. 126-130.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A. Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858. doi: [10.1038/35002501](https://doi.org/10.1038/35002501)

Olmos, F. and G.R.R. Brito. 2007. Aves da região da Barragem de Boa Esperança, médio rio Parnaíba, Brasil. *Revista Brasileira de Ornitologia* 15(1): 37-52. http://www4.museu-goeldi.br/revista_bornito/revista/index.php/BJO/article/viewFile/2802/pdf_446

Ploeg, A. 1991. Revision of the South American cichlid genus *Crenicichla* Heckel, 1840, with descriptions of fifteen new species and considerations on species groups, phylogeny and biogeography. Amsterdam: Academisch Proefschrift, Universiteit van Amsterdam. 153 pp.

Ramos, T.P.A. 2012. *Ictiofauna de água doce da bacia do rio Parnaíba*. [D.Sc. thesis]. João Pessoa: Universidade Federal da Paraíba. 435 pp.

Ramos, T.P.A., R.T.C. Ramos and S.A.Q.A. Ramos. 2014. Ichthyofauna of the Parnaíba river basin, northeastern Brazil. *Biota Neotropica* 14(1): 1-8. doi: [10.1590/S1676-06020140039](https://doi.org/10.1590/S1676-06020140039)

Reis, R.E., S.O. Kullander, J. Ferraris and J. Carl. 2003. *Check list of freshwater fishes of South and Central America*. Porto Alegre: Editora Universitária da Pontifícia Universidade Católica do Rio Grande do Sul. 729 pp.

Roberts, T.R. 1968. The fishes of the Rio Parnaíba. Fortaleza. 10 pp.

Rosa, R.S., N.A. Menezes, H.A. Britski, W.J.E.M. Costa and F. Groth. 2003. Diversidade, padrões de distribuição e conservação dos peixes da Caatinga; pp. 135-181, in: I.R. Leal, J.M.C. Silva and M. Tabarelli (eds.). *Ecologia e Conservação da Caatinga*. Recife: Editora da Universidade Federal de Pernambuco.

Santos, A.M.M. and M. Tabarelli. 2003. Variáreis múltiplas e desenho de unidades de conservação: uma prática urgente para a Caatinga; I.R. Leal, J.M.C. Silva and M. Tabarelli (eds.). *Ecologia e Conservação da Caatinga*. Recife: Editora da Universidade Federal de Pernambuco. 822 p.

Silva, V.M.A., R.M. Medeiros, D.C. Santos and M.F. Gomes-Filho. 2013. Variabilidade pluviométrica entre regimes diferenciados de precipitação no estado do Piauí. *Revista Brasileira de Geografia Física* 6(5): 1463-1475. <http://www.revista.ufpe.br/rbgfe/index.php/revista/article/view/773/484>

SRH/MMA. 2006. *Caderno da região hidrográfica do Parnaíba*. Brasília: Secretaria de Recursos Hídricos do Ministério do Meio Ambiente. 184 pp. http://www.mma.gov.br/estruturas/161_publicacao/161_publicacao03032011023605.pdf

Vanzolini, P.E. 1992. Paleoclimas e especiação em animais da América do Sul tropical. *Estudos Avançados* 6(15): 4165. doi: [10.1590/S0103-40141992000200003](https://doi.org/10.1590/S0103-40141992000200003)

Zarske, A., P.Y. Le Bail and J. Géry. 2006. New and poorly known characiform fishes from French Guiana. 1. Two new tetras of the genera *Hemigrammus* and *Hyphessobrycon* (Teleostei: Characiformes: Characidae). *Zoologische Abhandlungen* 55: 17–30. http://www.senckenberg.de/files/content/forschung/abteilung/tierkunde/ichthyologie/publikationen/112_hyp_borealis_hem_ora.pdf

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